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BETTER GRAIN-SORGHUM CROPS.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., March 13, 1911.

SIR: I have the honor to transmit and to recommend for publication as a Farmers' Bulletin the accompanying manuscript on "Better Grain-Sorghum Crops," prepared by Mr. Carleton R. Ball, Agronomist in Charge of Grain-Sorghum Investigations, under the direction of Mr. M. A. Carleton, Cerealist in Charge of Grain Investigations.

The areas devoted to grain sorghums in the dry regions of the Southwest are rapidly increasing. The importance of these crops, however, is even greater than can be measured in terms of increased acreage. They are staple crops in much of the new dry-farming area of the southern Plains region and other parts of the Southwest. In many cases they are the chief dependence of the new settler, and their success or failure determines his ability to become established.

This paper presents the best known methods of improving the grain-sorghum crops on the farms where they are grown. These methods are simple and inexpensive of time or money, and are therefore within the reach of all farmers. More attention to the bettering of the quality and yields will be repaid as fully in these crops as in other cereals.

Respectfully,

WM. A. TAYLOR,
Acting Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

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BETTER GRAIN-SORGHUM CROPS

INTRODUCTION.

The aim of this paper is to tell the farmer who is growing grain sorghums how he can best improve these crops. By grain sorghums is meant all the different varieties of the groups of sorghums called milo, kafir, durra, and kowliang. Of these groups only the kafirs are grown to any extent for forage, apart from the grain. The other groups are grown almost wholly for the yields of grain.

By improvement is meant changes both in the habits of the plants themselves and in the methods of handling them. These changes must be such as will make them better yielders or otherwise better adapted to the needs of the grower. Some of these changes will be in the matter of purer varieties, greater drought resistance, increased earliness, dwarfer stature, better heads, thinner seeding, and machine harvesting.

In many localities unimproved varieties of grain sorghums are being grown. Most farmers can improve their local varieties. Some of them do so to a very creditable extent; others neglect this entirely. Such work should be much more generally done, and probably would be if the methods of doing it were more commonly understood. In other communities improved varieties have been introduced and are grown by most of the farmers. The work of improving them must be continued by the growers, however, or the varieties are likely to become gradually poorer. This is caused by accidental mixtures of seed or by crossing with other varieties or with unimproved strains of the same variety.

The annual loss from smut is serious, in the kafir varieties, especially, though it may readily be prevented. The milo varieties are not affected by smut under any circumstances.

Before taking up the study of methods of improvement it is desirable to consider the region in which these crops are grown and to know something of their origin, history, general adaptations, and importance.

THE GRAIN-SORGHUM BELT.

The grain sorghums are most largely grown in the southern half of the Great Plains region (fig. 1).

BOUNDARIES.

Broadly speaking, this region includes the plain lying between the ninety-eighth meridian of longitude and the Rocky Mountains. The southern half of it may be said to include the area between the

northern boundary of Kansas and the Mexican border, although the extreme southern part of western Texas does not belong to the Plains proper. The area thus bounded takes in the western half of Kansas, the western third of Oklahoma, the western half of Texas, and all of Colorado and New Mexico lying east of the mountains. In round

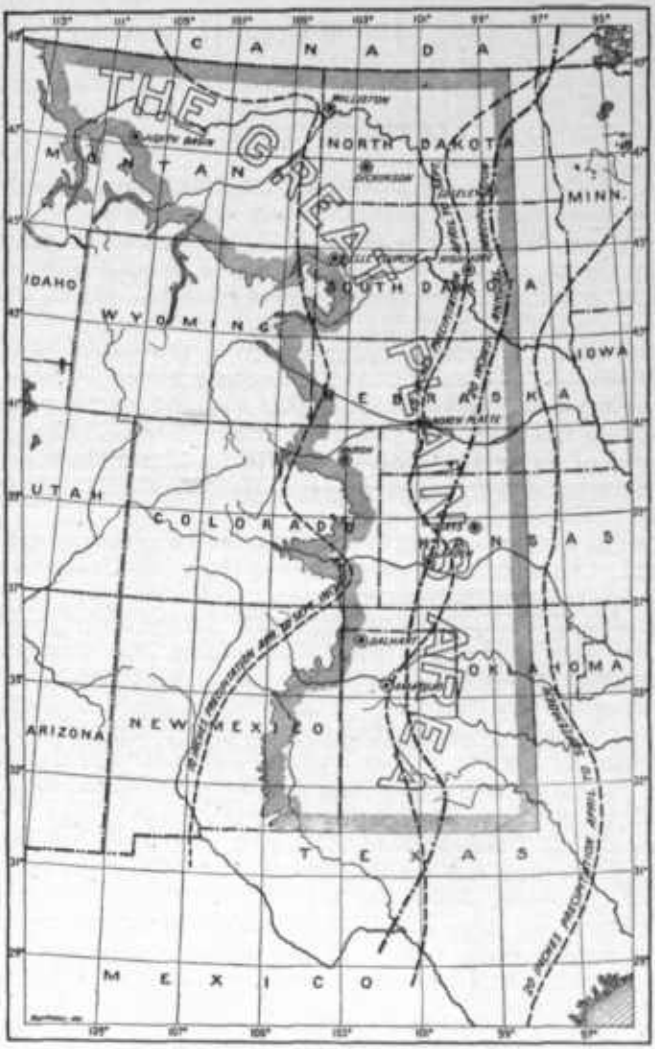

FIG. 1.—Map of the Great Plains area, showing the annual and the seasonal rainfall.

numbers it is 400 miles wide and 1,000 miles long. So important are these crops in this area that it may well be called the "grain-sorghum belt."

SURFACE FEATURES.

The surface of the area just outlined is in general a gently rolling plain, sloping steadily eastward from an elevation of 4,000 to 5,000 feet at the base of the Rockies to an average elevation of 1,000 to

1,500 feet at the ninety-eighth meridian. The highest section in these plains is not at the base of the mountains but some distance east of them, in Elbert and El Paso Counties, Colo., where the altitude increases to nearly or quite 6,500 feet. While the main slope is toward the east, there is also a secondary slope to the north and south from this high area in Colorado. Looked at from above, the surface of the whole Great Plains region may be compared in outline to half of an inverted saucer, the rim lying toward the east.

SOILS AND PLANT COVERING.

The soils of this region vary from the dark clays of the central Panhandle and the red clays of western Oklahoma, through sandy loams found in scattered areas throughout the whole region, to very sandy soils such as characterize the sand-hill country of Kansas and Colorado.

The plant covering of the loams and clays is mostly a dense sod of buffalo grass and blue grama mixed. In general these are called "tight" lands or "short-grass" country. In southwest Texas the buffalo grass gives place to the curly mesquite (*Hilaria cenchroides*), or running mesquite, as it is often called. On the more sandy soils are found taller and more bunchy grasses, such as the bluestems (*Andropogon* spp.) and the needle grasses, or wire-grasses (*Aristida* spp.). In much of western Texas the plains have been largely covered by a more or less dense growth of the mesquite tree (Prosopis). In southern Texas this becomes a large tree, but as it ascends to the higher plains its size diminishes until in the upper Panhandle it is only a low shrub or bush.

CLIMATE.

What really separates the so-called Great Plains region from the country lying immediately east of it is, primarily, not differences in either elevation or soil, but the lower rainfall and higher evaporation of moisture. The average annual rainfall for the grain-sorghum belt, as defined above, is about 20 inches, varying in different parts from 15 to 25 inches, of which more than half comes in the months of April to September, inclusive. (See fig. 1.) The summer temperature is fairly high, and this, with the steady winds which prevail over much of this area, makes evaporation rapid and continuous.

All crops to be suitable for use in this area must have the ability either to withstand or to escape drought in one way or another. Dry, hot winds occasionally occur in some parts of the region, often quickly and completely destroying all tender vegetation. At the higher elevations and in the northern part generally the season is comparatively short. Late spring frosts occur and the first frosts of autumn come rather early. Early varieties must therefore be used.

AGRICULTURAL DEVELOPMENT.

The process of dividing the great cattle ranges and selling them for farms is going on steadily. Wherever Government land remains, homesteads are being taken up. In the past few years the settlement of this dry country has been very rapid. Rapid settlement

may be desirable; it is much more important, however, that it be permanent. This has not always been the case. More than once considerable areas have been largely abandoned after having been quite well settled and improved. The abandoned farms reverted first to weed crops and finally to grass and sod. These conditions were true in the early eighties and again in the early nineties. The principal cause was a series of unusually dry seasons. Loss of crops starved out many settlers who had little capital to carry them through such crises.

It is quite probable that such unfavorable periods will occur again. Plains settlers must prepare to endure them with as little loss as possible. In two important ways the farmer is much better equipped than he was 15 or 20 years ago. Better and more drought-resistant crops and crop varieties have been found or produced, and better methods of tilling the land in dry regions have been developed.

No one may say with certainty just what the agricultural future of this southern Plains region is to be. It gives promise of becoming a second great feeding belt, similar to the corn belt. The comparatively mild winters and nutritious grasses which made it a famous grazing country will help to make it a famous feeding area. It is true that the native range carries only one head of stock the year round on each 25 to 50 acres, owing to the small size and slow growth of the grasses. However, the carrying capacity per acre may be enormously increased by supplementing the native pasture with crops supplying forage and feeding grains.

Nothing better could be wished than that this area should grow stock and the crops to feed them. Under such a system of farming it would produce many more live stock than it ever did or could under the ranch and range system. If it should raise a money crop in addition, so much the better. This might be cotton in the southern part, winter wheat in the central, and spring wheat in the northern part, with broom corn and other minor crops in different parts. The area is admirably adapted to growing both the stock and the necessary feeding crops.

IMPORTANCE OF THE GRAIN-SORGHUM CROP.

The following pages give briefly the history of the grain sorghums in the United States, the general conditions to which they are adapted, and some statistics of their acreage, yield, and value.

HISTORY OF THE VARIETIES.

It is only 35 years since the first grain sorghums (fig. 2) were introduced into the United States. It is only 20 years since any of them have become crops of recognized importance. Although grain-producing varieties had probably been introduced from time to time since the early colonial days, none had remained in cultivation.

The first permanent introductions were the two durras, Brown durra and White durra, which reached California in 1874 under the names "Brown Egyptian corn" and "White Egyptian corn." On account of its earliness and drought resistance, the white variety became popular in the central Plains region during two different series

of dry years. The first was from 1880 to 1884, when it was known as "Rice corn." Again, 10 years later, it was rather widely grown under the name "Jerusalem corn." Both the white and the brown varieties, but especially the white, are still sparingly grown in the dry Southwest, from Kansas to California. That they did not remain in general cultivation is probably due to the ready shattering of the seed when ripe and to the irritating hairs on the glumes.

Two varieties of kafir, the White and the Red, were brought from South Africa in 1876. They did not come into general cultivation in

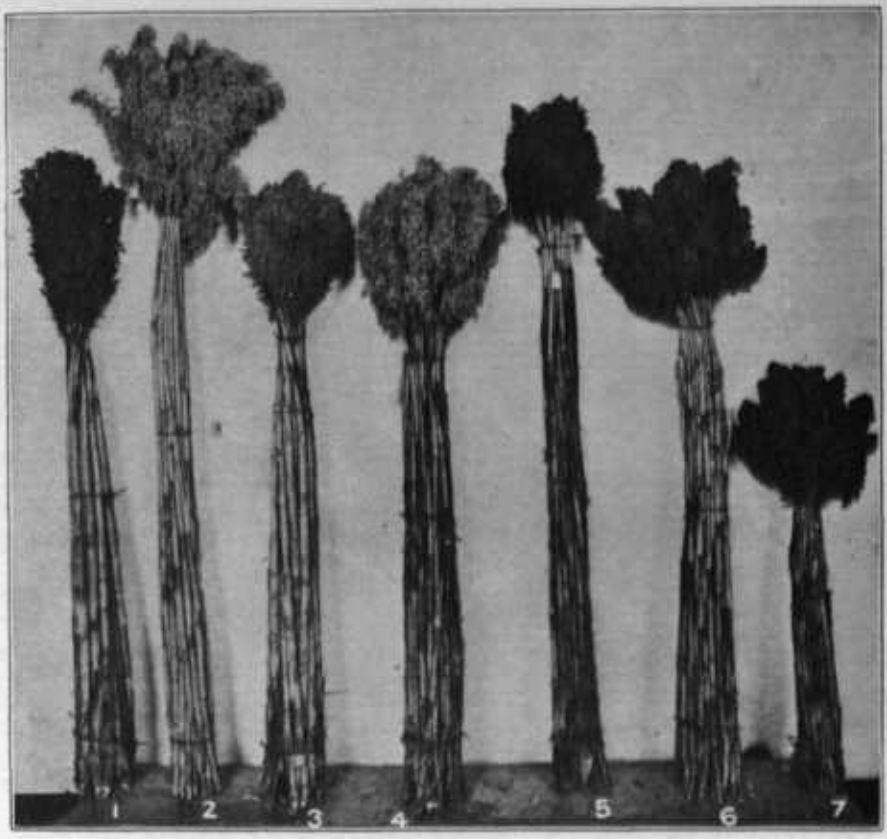

FIG. 2.—Sheaves of improved grain sorghums: 1, Red kafir; 2, Shallu; 3, Blackhull kafir; 4, White durra; 5, Brown kowliang; 6, Milo; 7, Dwarf Milo.

the Plains until about 1890, 14 years later. The Blackhull kafir appeared soon after, but whether it was a part of the original importation, separated by selection, or was a later introduction will probably never be known. The original White kafir is rarely found in cultivation to-day, but the Red and the Blackhull are important crops.

Milo was first introduced into South Carolina or Georgia about the year 1885, but did not come into general notice until about 1890, when it had become a staple crop in parts of west Texas.

The kowliangs have been coming from China and Manchuria since 1901. Most of them have required considerable selection to make

them suitable for use as grain crops. None of them has been long enough in the hands of farmers to be considered a farm crop.

In the brief space of the last 20 years, however, the milos and kafirs have greatly increased in importance. They are now grown as staple farm crops on a large scale in a considerable area of the West.

ADAPTATIONS TO THE GRAIN-SORGHUM BELT.

It is in the region described that the grain sorghums prove themselves most completely at home. They are not only staple crops here, but are in many cases the chief dependence of the new settler. This is because they may be grown as sod crops. By homesteaders with small means and limited equipment they can be cheaply planted on breaking. They are often planted, cultivated, harvested, and even thrashed by hand under such circumstances.

When these crops were first introduced they were tried in various parts of the United States. One after another they were found unsuited to the conditions in most of the country and were discarded; but out on the Plains they grew in favor with the farmer because they were able to withstand the prevailing conditions. They are able to grow and make profitable yields in hotter, drier climates than most crops. Some of them are early enough for use at comparatively high elevations. They are all cultivated crops, entering readily into the rotation with spring-sown small grains. They furnish the feeding grain required on the farm; also some roughage, and occasionally both fuel and food in addition. The surplus can always be sold at fair to good prices. When grown on a large scale they are handled rapidly and profitably by machinery in every necessary operation from seeding to milling. They are undoubtedly suited to become the basis of a cattle-feeding industry that will make the Plains farmer prosperous.

USES OF THE GRAIN.

STOCK FEED.

Primarily these grains are and ought to be used in feeding stock on the farms where they are grown. This fact is due to their history as well as to their adaptations for such use. They were the principal crops of the early settler in the dry-land areas of the southern Plains region. He not only needed a feeding grain, but was often too far from market to sell profitably if he had wished.

The value of the grain for keeping work stock, growing animals, and dairy cows in excellent condition has long been recognized among the growers. The knowledge of its value in fattening cattle and hogs for market is increasing. A number of experiments to determine the feeding value have been conducted at the agricultural experiment stations of Kansas,[1] Oklahoma,[2] and Texas.[3] In many of these trials

[1] Experiments with Kafir Corn; Bulletin 56, Kansas Agricultural Experiment Station, 1895, pp. 165–167.

[2] Digestion Experiments and Fodder Analyses; Bulletin 37, Oklahoma Agricultural Experiment Station, 1899, pp. 1–20. Summary of Digestion Experiments with Kafir; Bulletin 35, Oklahoma Agricultural Experiment Station, 1898, pp. 1–4. Digestion Trials; Bulletin 46, Oklahoma Agricultural Experiment Station, 1900, pp. 1–8.

[3] Information Regarding the New Feed Law; Bulletin 95, Texas Agricultural Experiment Station, 1907, pp. 1–24. Kafir Corn and Milo Maize for Fattening Cattle; Bulletin 97, Texas Agricultural Experiment Station, 1907, pp. 1–20. Digestion Experiments; Bulletin 104, Texas Agricultural Experiment Station, 1908, pp. 1–33. Steer-Feeding Experiments; Bulletin 110, Texas Agricultural Experiment Station, 1908, pp. 1–23. Panhandle Feeds for Beef Production; an unnumbered and undated circular of 7 pages of the Texas Agricultural Experiment Station.

the Blackhull-kafir grain, which was most generally used, was shown to have a feeding value but little below that of corn. Chemical analyses of the grain show it to contain slightly more protein and starch and a little less fat and fiber than corn. The somewhat lower feeding value seems to be due to lower digestibility rather than to any particular difference in composition.

The grain should be carefully ground before feeding in order to get the best results. In the form of milo chops and kafir chops it is becoming a popular commercial article. Chops are made by grinding or crushing the thrashed grain more or less finely. Head chops are made by chopping or grinding coarsely the unthrashed heads, and are therefore similar to corn-and-cob meal. Head chops are not meeting with as much favor as chops because they contain considerable so-

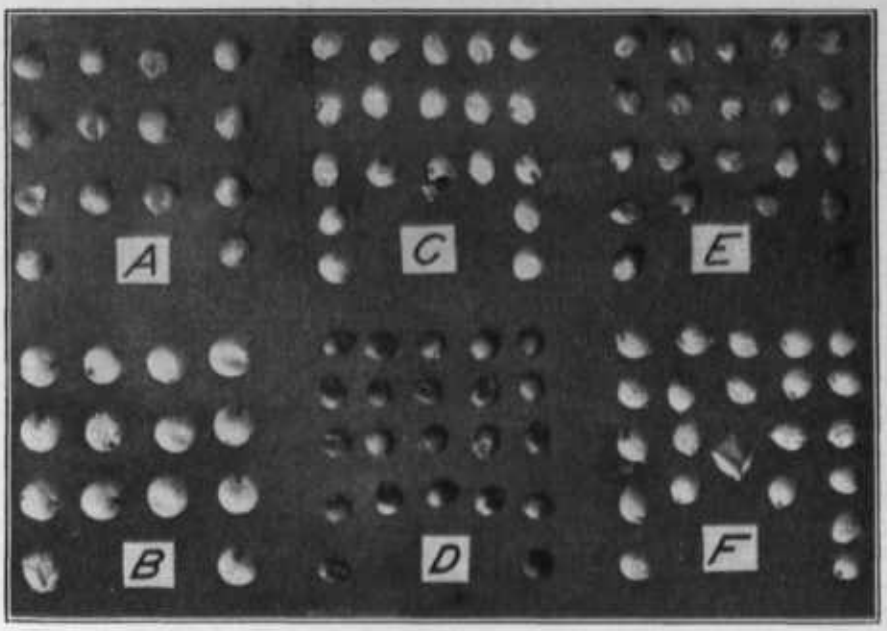

FIG. 3.—Seeds of grain sorghums: *A*, Milo; *B*, White durra; *C*, Blackhull kafir; *D*, Red kafir; *E*, Brown kowliang; *F*, Shallu. (Natural size.)

called "dirt," which is composed of the glume hairs, awns, and fragments of the glumes and branches of the heads. For this reason many grain elevators in the Plains region have been equipped with machinery for thrashing and grinding these grains. They are thus enabled to buy these crops in the head and to thrash and grind them at their leisure in order to prepare them for the market.

POULTRY FEED.

The grain-sorghum seeds (fig. 3) are splendidly adapted, both in size and composition, for feeding to all classes of poultry. In many parts of the country, far outside of the grain-sorghum belt, small patches of kafir, durra, or other "chicken corn" are commonly grown on the farm, simply to furnish chicken feed. There were in 1908 more

than 100 firms engaged in the manufacture of over 200 brands of poultry food. Figures furnished by 33 of these firms show an annual output at that time of about 30,000 tons of these products. Approximately 10,000 tons, or one-third of this total, consisted of the seed of Blackhull kafir. This was mostly used in mixture with other grains, such as corn, wheat, screenings, etc. It is probably a conservative estimate that kafir or other grain-sorghum seed forms fully 25 per cent of the prepared poultry food sold in this country. So strong is the demand for these grains by the manufacturers of poultry food that similar varieties have been imported from as far away as India when the crop in this country was short. Considerable quantities were so imported in the winter of 1909–10, following the short crop of 1909.

HUMAN FOOD.

Meal made from the grain sorghums, ground locally, is not infrequently used in the making of batter cakes and similar articles on the farm. The general testimony is that these are delicious in quality. Some experiments are now being conducted in a small way to determine the value of the meal for more extended use. There seems little reason why, when properly milled, it should not be used in much the same manner as corn meal. Throughout Africa, India, and the other parts of southern and eastern Asia, where these crops are largely grown, they are not only commonly used as human food, but in many countries they furnish the chief article of diet.

STATISTICS OF ACREAGE, YIELD, AND VALUE.

Complete statistics of the production of these crops are not available. The national census, taken every 10 years, has not yet separated them in its schedules from other related crops. Of the five or six States which grow them largely only two gather State statistics of farm crops. These two are Kansas and Oklahoma. The figures have been gathered in Kansas since 1893, but in Oklahoma only since 1904 for kafirs and since 1905 for milo. The facts given below have been compiled and adapted from the figures published by the boards of agriculture of these two States.

TOTAL GRAIN-SORGHUM CROP IN KANSAS AND OKLAHOMA.

In Kansas the acreage of kafirs and milo has increased from about half a million acres in 1904 to nearly three-fourths of a million acres in 1909. In that State the yield is estimated in tons of fodder, and the average for the last six years has been 3 tons per acre. The average value of these crops per acre for the same period has been $10.28. Although the average yield per acre does not seem to be increasing, the average acre value is rising; for the first three years of this period it was $9.60, for the last three years it was $10.95.

The records for the present State of Oklahoma are not complete. From 1904 to 1906, inclusive, the figures are for only the old Territory of Oklahoma; for 1907 to 1909 they are for the entire new State, including the former Indian Territory. The area devoted to these crops has increased from 500,000 acres in 1907 to nearly 700,000

acres in 1909. The yield of grain during the six years from 1904 to 1909, inclusive, averaged 11.6 bushels to the acre. The average acre value of these crops during that period was $5.68. No account was taken of the value of the stalks until the year 1908. In that year the value of the kafir stalks was found to be nearly one-half as much as the value of the grain, or nearly one-third the combined value of grain and stover. In the case of the milo crop, the stalk value was exactly one-fourth the grain value or one-fifth of the combined value. It is not clear from the State reports whether the fodder and grain represent the product of the same field or whether the figures for fodder are based on fields not harvested for the grain. It has been assumed that the former was intended.

KAFIR, MILO, AND CORN CROPS IN KANSAS AND OKLAHOMA.

In 1904 there were only 7,000 acres of milo in Kansas. By 1909 this had increased to more than 100,000 acres. During this six-year period the average yield was 2½ tons per acre, the average value per ton $3.87, and the average acre value $9.52.

In the same period the acreage devoted to kafirs had increased from 500,000 to 636,000 acres, with an average yield of 3 tons per acre and an average price of $3.48 per ton. The average acre value was $10.33.

During the same period the corn acreage had increased from 6,500,000 acres to 7,750,000 acres, giving an average yield of 23.1 bushels; the average selling price was 44 cents per bushel, and the average acre value $9.83.

Owing to the reasons already stated the figures for Oklahoma can not readily be compared. However, in 1909 there were 203,000 acres of milo with an average yield during the five-year period of 13.8 bushels, an average selling price of 44 cents per bushel, and an average acre value of $6.31.

The year 1909 showed 482,000 acres of kafir, with a six-year average yield of 11 bushels, an average value of 45 cents per bushel, and an average acre value of $5.56.

There were 5,135,000 acres of corn grown in 1909. The average yield for the six years from 1904 to 1909 was 19.45 bushels, the average price 43.5 cents per bushel, and the average acre value $8.29.

The proportion of grain sorghums to corn grown in these States is steadily increasing with the settlement of the drier western portions. The average acreage of grain sorghums for the period from 1904 to 1909 in Kansas was equal to 8.7 per cent of the average corn acreage. For the year 1909 alone it had increased to 9.6 per cent in spite of an enormous increase in the corn acreage. In Oklahoma the same figures are not comparable because of the change from a small territory to a larger State. However, the average grain-sorghum acreage in the old Territory from 1904 to 1906 was equal to 25.6 per cent of the corn area. In 1907, in the new State, including both Oklahoma and Indian Territories, it was 12.5 per cent; in 1908, 12.7 per cent; and in 1909, 13.4 per cent. The sudden decrease at the beginning of the second period is due to the fact that the area comprising the former Indian Territory grows much corn and little grain sorghum.

As already pointed out, the grain sorghums are all grown most extensively in the drier areas west of the ninety-eighth meridian. In Kansas, during the period from 1907 to 1909, inclusive, about 94 per cent of the milo, about 45 per cent of the kafir, and about 25 per cent of the corn were found west of this line, which divides the State almost exactly in half. In Oklahoma about one-third of the State lies west of this line and contains 97 per cent of the milo and 79 per cent of the kafir, based on averages of five and six years, respectively.

The 46 counties in the western half of Kansas grew, in round numbers, 240,000 acres of grain sorghums in 1907, 334,000 acres in 1908, and 396,000 acres in 1909. This was an increase of 39 per cent in the grain-sorghum acreage for 1908 and of 18.6 per cent for 1909. The same counties grew 1,500,000 acres of corn in 1907, 1,750,000 acres in 1908, and 2,000,000 acres in 1909, increases of 17 and 14 per cent, respectively. The ratio of the acreage of grain sorghums to that of corn was 1 to 6.2 in 1907, 1 to 5.3 in 1908, and 1 to 5.1 in 1909. The grain-sorghum acreage was therefore equal to 16.1 per cent, 18.9 per cent, and 19.5 per cent of the corn acreage of these three years, respectively. Ten of these counties grow larger areas of grain sorghum than of corn.

In the 21 counties now comprising the western third of Oklahoma there were grown 327,000 acres of grain sorghum in 1906, 423,000 acres in 1907, 465,000 acres in 1908, and 580,000 acres in 1909, increases of 29, 10, and 25 per cent, respectively. The ratio of grain-sorghum acreage to that of corn was 1 to 2.1 in 1906, 1 to 2.7 in 1907, 1 to 3.1 in 1908, and 1 to 3.07 in 1909. These ratios represent grain-sorghum acreages equal to 47.6 per cent, 37 per cent, 32.2 per cent, and 32.6 per cent of the corn acreages for the same years. Three or four of these counties grow more grain sorghums than corn.

SUMMARY OF THE VALUES OF GRAIN SORGHUMS AND CORN.

In Table I is given the minimum, maximum, and average value per acre of the grain-sorghum and corn crops in Kansas and Oklahoma. It will be noted that for Kansas the minimum acre value of the combined grain sorghums is not as low as the minimum for corn; that the maximum is nearly as high, and that the average acre value is higher by 45 cents an acre. In Oklahoma the facts are exactly reversed.

Two facts must be kept in mind while comparing these figures. One is that for Kansas the yields and values of grain sorghums are based on tons per acre and thus include the value of both grain and stover. The yields and values of corn, on the contrary, are based on bushels of grain per acre. If the value of the corn stover were also included, the average acre value for corn would probably somewhat exceed that of the grain sorghums. The difference, however, would probably not be as large as in the case of the Oklahoma figures. The other fact is that the grain sorghums are most largely grown in the western parts of these States. Here the shorter seasons and lower rainfall tend to decrease the yields of all crops. This puts the sorghums at a disadvantage in a comparison with corn, which is most extensively grown in the lower and more humid portions.

TABLE I.—*Summary of value of grain sorghums and corn in Kansas and Oklahoma.*

State and crop.	Number of years averaged.	Yield per acre.	Price.	Acre value.				
				Minimum.		Maximum.		Average for period.
				Year.	Value.	Year.	Value.	
Kansas:		*Tons.*	*Per ton.*					
Kafir	6	2.99	$3.48	1906	$9.18	1909	$11.21	$10.33
Milo	6	2.53	3.87	1906	8.31	1907	10.61	9.52
Total grain sorghums	6	2.95	3.48	1906	9.16	1907	11.10	10.28
		Bushels.	*Per bu.*					
Corn	6	33.1	.44	1904	7.81	1908	11.71	9.83
Oklahoma:								
Kafir	6	11.0	.45	1904	3.92	1907	7.77	5.56
Milo	5	13.8	.44	1909	2.55	1907	8.64	6.31
Total grain sorghums	6	11.6	.45	1904	3.92	1907	8.00	5.68
Corn	6	19.4	.43	1904	6.24	1906	11.21	8.29

IMPROVING THE GRAIN SORGHUMS.

In general there are two ways by which the grain-sorghum crops can be made of greater value to the grower. The first is by improving the varieties; the second, by finding more rapid and economical methods of harvesting. Improved varieties can be obtained through selection of present sorts and by bettering the methods of growing them. More rapid and economical harvesting will come about either through adapting the crops (fig. 4) to present machinery or through the invention of new machines, or both.

There are five principal ways in which improvement may be made: (1) Increased drought resistance, (2) increased earliness, (3) dwarfer stature, (4) greater productiveness, and (5) increased machine harvesting.

DROUGHT RESISTANCE.

The grain sorghums are most useful in regions where moisture is often the controlling factor in crop production. Much good should therefore be accomplished by increasing their drought resistance, especially in the areas of lighter rainfall.

No one knows exactly what drought resistance is. It is probable that what we call drought resistance is the effect of several different factors. The most important of these factors are probably (1) increased ability to prevent the loss of water by transpiration, (2) increased development of the root system, and (3) a possible increase in power to extract water from a dry soil.

Differences in the power to control transpiration are well-known and readily observed facts. By transpiration is meant the passing of water from the tissues of the plant into the air. In the processes of their growth all plants are constantly absorbing water from the soil through their rootlets and allowing certain quantities of this moisture to pass out into the air through minute pores, called stomata. This is done in much the same manner as water escapes through the animal skin in the form of perspiration. In times of drought it is important that the plant lose as little as possible of its

water supply in this way. The plant best fitted to prevent transpiration is thus the most drought resistant. In cacti, for instance, this ability is highly perfected. Corn is much less drought resistant than the members of the various groups of sorghums. Corn is in danger when the leaves begin to curl, but sorghums often remain in this condition for a long time without permanent injury.

The size and character of the root system is probably a strong factor in drought resistance. The larger the root system in proportion to the plant, the better it can supply moisture. The wider and deeper its penetration, the larger the area of soil from which it draws

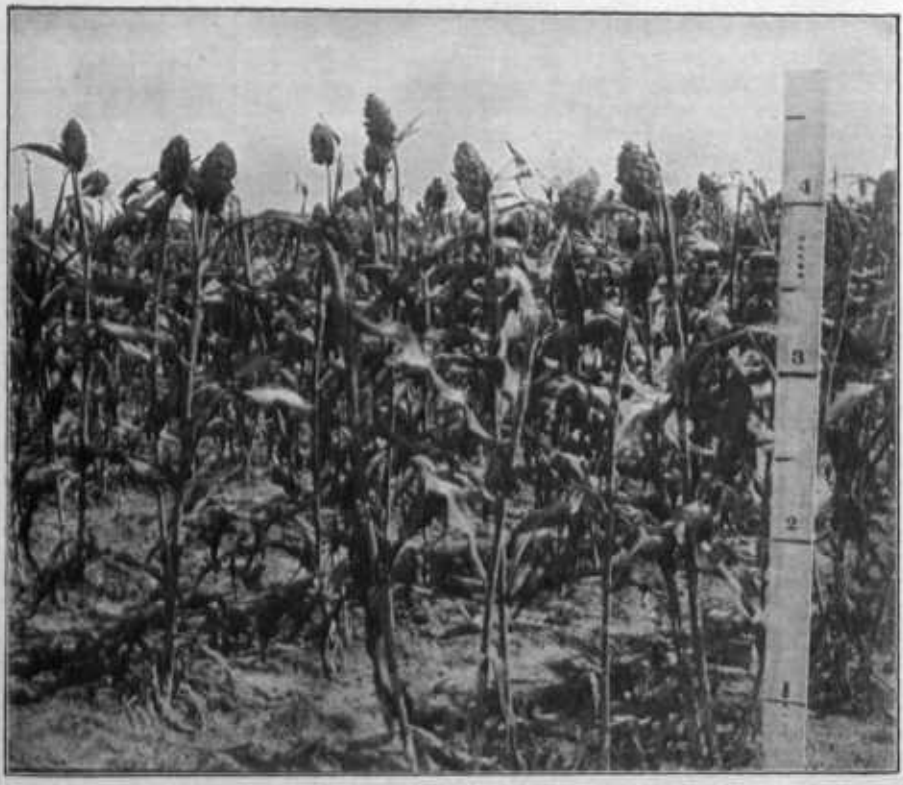

FIG. 4.—Plat of milo, selected for erect heads and low stature.

moisture in time of drought. A deeply rooting plant may be able to secure water when shallow root systems lie wholly in dry soil. This is entirely apart from possible differences in ability to extract moisture from a given unit of soil. Such differences may exist, but the idea is only a theory as yet. Unfortunately, the character of the root system can not be observed while making selections.

Selections for drought resistance will naturally be made on conditions that can be seen with the eye. These are likely to be the results of a combination of means for actually resisting drought and for evading drought. Dwarfness, earliness, and thin stands are means or conditions for drought evasion. By making allowance for them,

when present, one can select for actual drought resistance. This will be done by using those plants which give best results under drought conditions when they are neither dwarfer nor earlier nor more thinly planted than their neighbors.

EARLINESS.

There are two principal reasons for desiring early varieties. The first is to extend the range of grain sorghums into dry regions having a short growing season. The second is to secure the fullest possible benefit from the seasonal rainfall, which comes largely during the early summer months in parts of the grain-sorghum belt. The second reason is thus connected with the problem of drought resistance, though, as pointed out, earliness is a means of drought evasion, not of resistance. Improvement in earliness will need to be continued for a long time if varieties are to be perfected for the needs of all the dry-farming regions.

EARLY VARIETIES.

The milos are much earlier varieties than the kafirs and are very promising material on which to work. In the Panhandle of Texas, at elevations of 3,000 to 4,000 feet, they now mature in 90 to 100 days when sown May 15 to 20. At present they are grown successfully up to an altitude of between 4,000 and 5,000 feet in Texas, New Mexico, and Colorado. At higher elevations the growing season is shortened to such an extent that the present varieties of milo do not mature. At lower elevations their present range extends northward into southwestern Nebraska. In northern Nebraska, the Dakotas, Montana, and Idaho the increasing latitude and shorter growing season prevent their successful maturing. It seems certain, also, that the soil, especially at night, is too cool to permit vigorous growth, thus retarding the maturing of the plant even where the season is otherwise long enough.

The durra group contains some very early varieties. The only one well known in this country is the common White durra (fig. 5), which has been called "White Egyptian corn," "Rice corn," and "Jerusalem corn" in the successive periods of its popularity. It matures as early as or slightly earlier than the milos. White durra apparently possesses true drought resistance also and is a good yielder, but shatters quite badly and is not liked for that reason and some others. Some hybrids of this variety with Blackhull kafir have been under selection for three years and give promise of being valuable.

The kafirs usually require about three weeks longer than milo to mature under the same conditions. An early strain of Blackhull kafir developed by the writer, through selection, matures about two weeks earlier than the ordinary kafirs and only three to five days later than milo. The old-fashioned White kafir with white hulls, now rarely found in cultivation, was a semi-early sort and would make good selection stock if its heads were free from the boot and if it was not so readily attacked by diseases. Red kafir, which is normally a week or more earlier than the Blackhull in the low plains, seems

to become proportionally later as it is carried westward to higher elevations. At the Amarillo Experiment Farm it has been consistently later than the Blackhull variety during a period of several years.

The group of kowliangs from northern China and Manchuria contains some varieties (fig. 6) which are naturally very early, especially among the brown-seeded sorts. Three of these (Grain Investigations Nos. 171, 261, and 328) have matured in 80 to 90 days, thus proving earlier than the milos in the Panhandle of Texas. Some promising selections from them have been made in northern Colorado, in Nebraska, and in South Dakota. Coming, as they do, from lati-

FIG. 5.—Plat of White durra with 100 per cent of the heads erect.

tude 40° or higher, they may prove able to germinate and grow at lower temperatures than the groups which have come from more southern latitudes.

EARLY CROPS AND EARLY SEASONAL RAINFALL.

The effect of earliness in permitting drought evasion is very important. Consider two plants, one earlier than the other, but otherwise similar in all respects. The earlier plant, having a shorter growing period, not only uses less water, but uses it earlier in the season. This is of especial importance in those parts of the semiarid country where much of the seasonal rainfall occurs in April, May, and June. The earlier plant might be able to mature its crop of seed on the summer rainfall. On the other hand, the later plant might be crippled at a critical stage by the exhaustion of the soil moisture dur-

ing dry weather in August. It is fairly certain that in much of the Plains region the greater part of the soil moisture in a field is not used by the growing plants, but is lost by evaporation under the average tillage conditions.

Milos are earlier than kafirs, but are not known to be more truly drought resistant. At Amarillo, Tex., under conditions of severe drought from the middle of July until October, 1909, the milos yielded on the average 8.3 bushels and the kafirs only 5.5 bushels to the acre. In each crop the figures are the average of between 20 and 30 plats and show that the difference was really in the earliness (and perhaps dwarfness, also) of the milos as compared with the kafirs, the yields in normal years being about equal.

FIG. 6.—Plat of selected Brown kowliang (G. I. No. 171).

The season of 1910 was still drier, only 10 inches of rain falling at Amarillo from January to October, inclusive. Better yields were obtained than in 1909, however, because the average stands were much thinner. Under these conditions 32 plats of milo and Dwarf milo yielded an average of 17.9 bushels per acre, while 22 plats of ordinary Blackhull and Red kafirs yielded only 3.7 bushels. The difference in average yield is 14.2 bushels. Even if we admit that half of this difference is due to the dwarfer growth of the milos compared with the standard kafirs, we still have a gain of 7.1 bushels due to earliness alone.

The relative values of earliness and dwarfness are further indicated in results obtained from three strains of Blackhull kafir. The writer has produced by selection an early strain of the Blackhull kafir which is nearly two weeks earlier than the ordinary strains, although of the same height. In 1908, a favorable season, it yielded about 10 per cent less than the average of the ordinary Blackhull varieties. In 1909, however, it yielded 10.7 bushels to the acre, while 20 ordinary strains averaged only 5 bushels and the best of them yielded only 10.9 bushels. In 1910, under the conditions described it produced 7.57 bushels compared with 2.95 bushels from 15 standard plats.

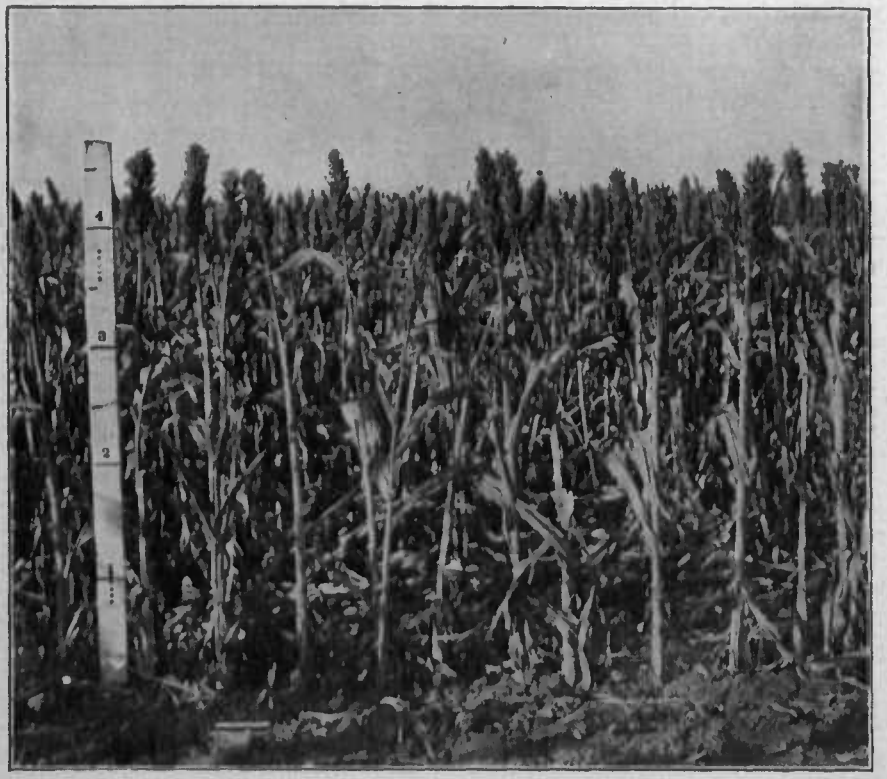

FIG. 7.—Plat of dwarf and early Blackhull kafir (G. I. No. 340).

Another early strain, which is also dwarf, growing to a height of about 4 feet (fig. 7), yielded in 1908 about 4.5 bushels less than the average of the ordinary taller and later strains. In 1909 it yielded 14.4 bushels compared with 10.7 bushels from the tall but early strain and an average of only 5 bushels from the ordinary taller and later strains. In 1910 it yielded 9.28 bushels, while, as noted above, the tall early strain produced 7.57 bushels and the ordinary strains only 2.95 bushels per acre. These figures indicate that in 1909 about 40 per cent and in 1910 about 27 per cent of its increased yields were due to its dwarfness and 60 per cent and 73 per cent, respectively, to its extra earliness.

SELECTING FOR EARLINESS.

Earliness can be developed only by continued selection. Such selections can be made either at heading time or at the time of ripening, but are preferably the results of records made at both periods. When the field or seed plat of the variety begins to head, a number of the earliest heads, which are otherwise suitable for selection, should be marked by means of tags on which is recorded the date of heading. When the heads on these selected stalks begin to show the characteristic colors and texture of the hard-dough or ripening stage, the date of ripening should be added to the tags. Other things being equal, those heads for which the shortest time has elapsed between heading and ripening are to be considered the earliest. These should be carefully saved separately and used for continuing the work another season.

In dry regions where the amount of moisture in the soil commonly controls the growth of the crop, the plants at the ends and sides of a field are often the first to produce heads, especially in dry seasons. This is because the outside plants have a larger area from which to draw moisture, or because run-off water often collects at the edges of fields and provides extra moisture. These early heads will be the first to ripen, but it does not follow that these plants are naturally earlier than the rest of the field.

DWARF STATURE.

For the grain-sorghum grower a dwarf variety has two advantages over the taller strains. It requires less water and can be harvested with a grain header.

The larger the plant the more water it requires and the more it is likely to lose by transpiration. A small plant which can produce as much grain as a large plant will thus have a real advantage in a dry season. This is not true drought resistance, but merely a lower water requirement which permits drought evasion.

As previously noted, the year 1909 was marked by severe drought during July, August, and September in the southern half of the Great Plains. At the Amarillo Experiment Farm, in Texas, 17 plats of milo gave an average yield of 6 8 bushels and 10 plats of dwarf milo an average yield of 11 bushels to the acre. The best plat of milo yielded at the rate of only 16.5 bushels, though in a low piece of ground, while the best dwarf milo yielded 23.2 bushels per acre. In 1910 there was not as much difference. Eight plats of milo yielded an average of 16.2 bushels per acre, and 7 plats of dwarf milo yielded an average of 19.6 bushels. The advantage in favor of the dwarf variety seemed to be largely due to the smaller size of the plants and the consequent lower water requirement.

The case of the dwarf and also early strain of the Blackhull kafir (fig. 7) has already been noted under the discussion of earliness. How much of its increased yield was due to dwarfness and how much to earlier maturity can not be certainly known. Apparently about one-third was due to its dwarfness and two-thirds to its earliness.

The production of dwarf varieties has made possible the use of the grain header in harvesting the crop. A few ingenious farmers have succeeded in raising their headers on timbers until they will cut, with

fair satisfaction, the ordinary tall varieties, but it is not likely to become a general practice. In case a successful row header is invented it is more likely to work well on low varieties than tall ones, especially in windy regions.

Selecting for dwarf stature raises the question of the ability of a plant to produce as large seed yields after the stalk and leaves have been reduced in size. How far can reduction in the size and height of stems be carried without reducing the total leaf area? How far can reduction of leaf area be carried without reducing grain production? These questions can not be answered except by long-continued investigations. The limits of profitable reduction in size will vary with climatic conditions of different regions. While these limits are not yet fully known for any region, there is fair proof that the standard varieties of the central Plains region can be much reduced

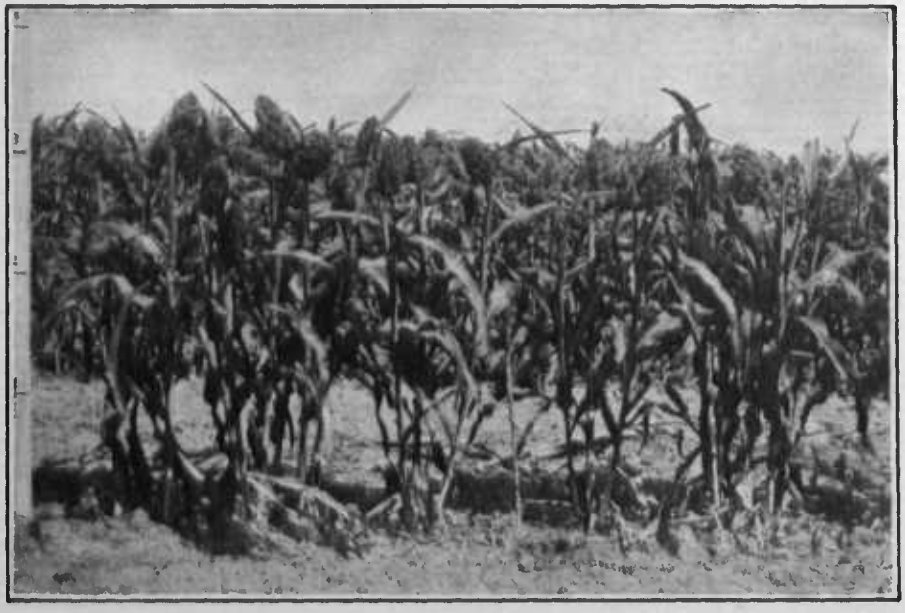

FIG. 8.—Plat of select Dwarf milo.

without passing the lower limit. The Dwarf milo (fig. 8) and Dwarf kafir are only 3 to 4 feet in height under conditions that make the normal crop 5 to 6 feet in height. The Dwarf milos outyield the standard milos even in favorable seasons. The White durra, which is low, yields as much as the kafirs, which are of medium height or taller. The Dwarf kafir, although recently produced, seems likely to hold its own in a series of years. An extra-dwarf Brown kowliang has been obtained in China. It grows to a height of about 2 feet, but, like most newly introduced sorghums, does not show high yielding power.

These crops have originated in subtropical lands and are commonly inclined to large growth. While they have been used chiefly for

grain production in their native homes, it has been by more or less primitive peoples, and the returns have not been large. Since coming to this country most of the standard varieties have been reduced in size and at the same time increased in yielding power. The limit of profitable dwarfness has probably not been reached; it certainly has not been passed.

PRODUCTIVENESS.

The two keys to increased grain yields are better varieties and better methods of growing them. Better varieties mean pure and smut-free crops, with better filled and perhaps larger heads, erect and fully exserted from the boot, borne on stalks with fewer suckers and no branches. Better methods relate to proper and even spacing of stalks in the row and to thorough cultivation of the growing crop. They also include proper rotations and suitable tillage of the land when not in crop. Selections for better yields may naturally be continued as long as the crop is grown. No one may say what returns will finally be obtained. We may reasonably hope, by continued effort, to increase greatly the present average yields.

PURE VARIETIES.

Extended travel and observation in the grain-sorghum belt show that many of the fields of different kafir and milo varieties are not pure. The same is true of the fields of sorgos or sweet sorghums and of broom corn. This condition comes from two causes, mixtures and hybrids. Usually both are present, because mixtures quickly result in hybrids.

The advantages of pure crops are many and easily seen. Pure varieties are most likely to be uniform in height and in time of ripening, and hence are easy to harvest. The grain is of much greater value for seed purposes and also obtains a higher grade and commands a better price on the grain market. It is also better as a feeding grain, because more uniform in quality.

Mixtures readily result from carelessness in cleaning empty bags, bins, wagons, and separators, or in storing the seed. Most of the mixing from these causes may be easily prevented. The presence of other varieties as volunteer crops in the fields is also a common cause of mixtures and one not so easily controlled. Early Amber sorgo and related strains are very common and troublesome volunteer crops in western Kansas and Oklahoma. The damage done by these mixtures of varieties can be largely remedied by roguing the fields; that is, removing by hand all plants not true to the variety grown. Where not possible to rogue an entire field, a part may be cleaned and the seed saved from that portion.

Crossing or hybridizing is more common in the sorghums than in most other farm crops. This is because they are all open fertilized; that is, intended to be cross fertilized by means of the wind. The three stamens (pollen-bearing or male part of the flower) and two pistils (pollen-receiving or female part of the flower) all appear outside the glumes or hulls of the flower in the early morning. The anthers or pollen sacs open at the end, and the pollen grains are quickly

emptied into the air as the anthers swing in the wind. The pollen is quite as likely to be carried on the breeze to the flower on some other plant as it is to fall upon the pistils projecting from the flowers on the same plant. The ease with which such crossing occurs is increased because these crops are most largely grown in regions of fairly constant winds and because their greater height enables the wind to carry the pollen farther than in the case of lower crops.

Crossing is likely to occur whenever two varieties are growing near each other if they are in flower at about the same time; hence, whenever mixtures of different varieties are found in a field, hybrids are almost certain to be formed and to appear in the crop the following year. In the grain-sorghum belt many of these are caused by the presence of Early Amber and other volunteer sorghum varieties in the fields of nearly all farms. Hybrids also result from planting the fields of different varieties too near together. Just how far apart the fields should be to insure safety from hybridizing is an open question. In the Great Plains area the prevailing winds are from the south and the alternating winds usually from the north. Crossing, therefore, takes place at greater distances in a north and south line than in an east and west line. Where two fields lie north and south from each other, a distance of 8 or 10 rods would probably be required, and 15 or 20 rods would be preferable. Where the fields lie east and west from each other, the crops would be fairly safe from crossing at shorter distances than those stated.

SMUT-FREE VARIETIES.

There are two kinds of smut affecting sorghums, head smut and kernel, or grain, smut. In the former the young head becomes a black mass of smut spores, inclosed at first in a grayish covering or membrane. In the kernel smut the seed is the only part visibly affected. The head looks much as usual except that in the case of white-seeded varieties it is much darker in appearance. The seeds are replaced by longer, gray smut kernels, full of black spores. These smuts occur on all kinds of sorghums except milos. Neither smut has ever been found on the varieties of the milo group.

The head smut is not very common, which is fortunate, because no means of controlling it is yet known. The kernel smut is quite common, and often completely destroys from 2 to 10 per cent of the heads in a field, reducing the yields of grain in the same proportion. It can easily be controlled by the modified hot-water treatment or by the use of formalin.[1]

BETTER YIELDING VARIETIES.

Better yielding varieties may come originally from an experiment station or other source, or they may be produced by the farmer himself from his own fields. In either case the grower must continue the selection from year to year. In its simplest form this will mean the selecting of stalks of desirable size and habit, bearing large and well-shaped heads (figs. 9 and 10), well loaded with plump grains. This requires, of course, that the work of selection be done in the field.

[1] Full directions for using these treatments are given in Circular 8, revised, Bureau of Plant Industry, U. S. Dept. of Agriculture, entitled "The Smuts of Sorghum," which may be obtained free on application to the Secretary of Agriculture.

Heads selected in the bin or crib tell little of the stalk on which they grew. The work should be done before harvesting begins and a sufficient quantity selected to furnish plenty of seed for the farm crop of the next year. Where early selection of seed has been neglected the selections may still be made during harvest, if harvesting is done by hand. A small box, fastened to the near side of the wagon bed, will serve to receive the selected heads. Careful selecting is not likely

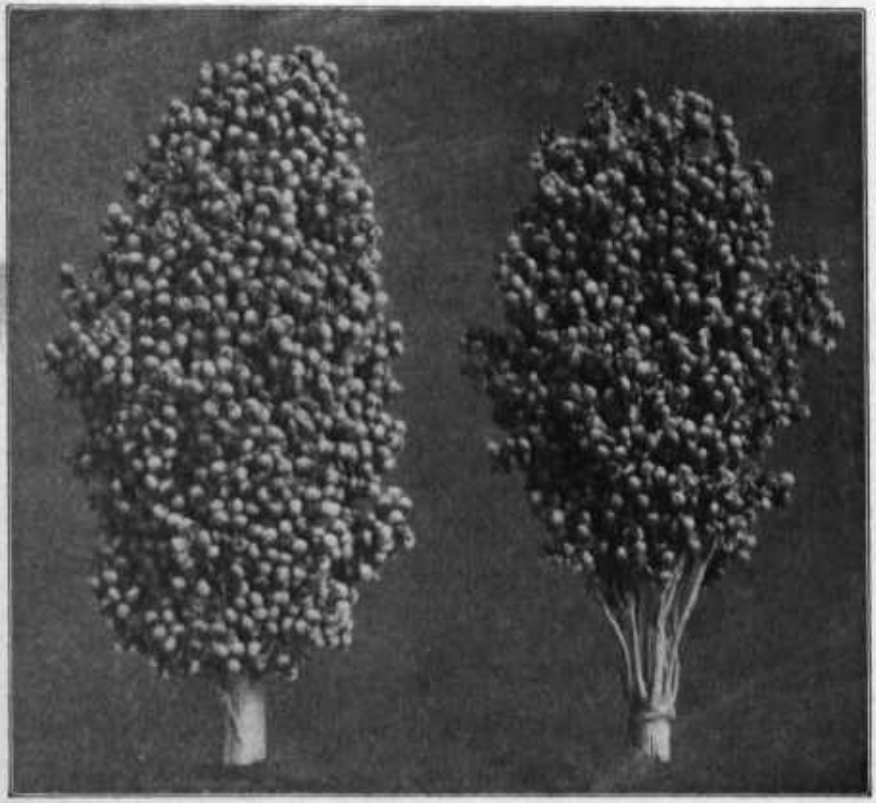

FIG. 9.—Two heads of milo, showing desirable and undesirable forms.

to be done, however, in the hurry of harvest. Where machine heading is practiced this method is, of course, not possible.

The selected heads may be hung up in a dry place or laid in thin layers on shelves and thrashed in the spring. If they are thrashed in the fall, the seed should be carefully stored in a cool room, and preferably in bags rather than in bins. There is much danger of lowering or destroying its vitality if it is allowed to heat.

Desirable Forms of Heads.

Well-filled heads.—It is important that the heads be well filled at the butts and tips, as in the case of corn ears. Less attention has been given to this matter than it deserves. Figure 9 shows desirable

and undesirable forms of milo heads, and figure 10 shows desirable heads of Blackhull kafir. Milo may be taken as representing durras also, while the kafir may be regarded as the proper shape for kowliangs as well. The poorer head contains less grain and is therefore less productive. It also contains a larger proportion of fiber and hence is less valuable as a feeding ration.

The heads selected should have shorter branches at the butt than in the rest of the head. These lower branches should be loaded with seed down to the point where they join the rachis or central stalk of

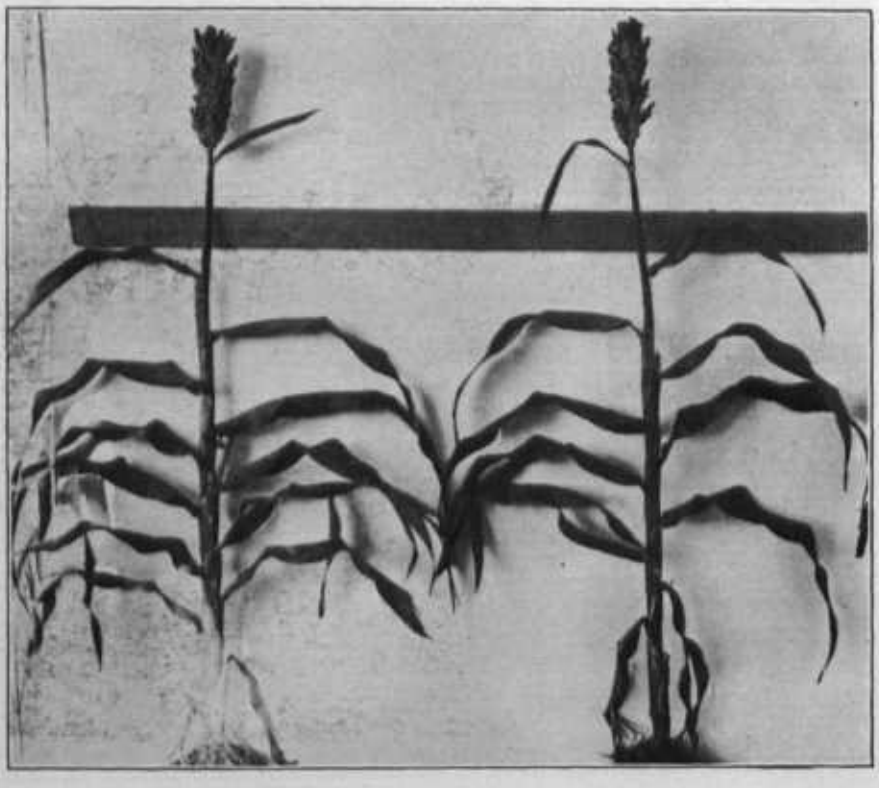

FIG. 10.—Two plants of Blackhull kafir, 5½ feet high, selected for high yielding power.

the head. Long basal branches are likely to droop and finally break away under the combined stress of weight and wind.

Fully exserted heads.—It is also important that the head be fully exserted from the boot, or upper leaf sheath. No seed is produced on the part not exserted, which often becomes moldy or rotten if wet weather prevails. Corn ear-worms (*Heliothis obsoleta*) and false army worms (*Laphygma frugiperda*) breed in such places and add to the injury. When these heads with spoiled butts are piled with others they are likely to cause damage to the whole heap. Varieties in which the heads are not fully exserted are also more difficult to harvest by hand or machine.

The main agricultural difference between White kafir and Blackhull kafir is that the heads of White kafir never become fully exserted from the boot. White kafir was the first kafir variety to come into general cultivation in this country, but it has since been almost wholly discarded, largely for this reason. Blackhull kafir, the present popular variety, bears the heads normally entirely free from the boot (fig. 10).

Large heads.—In selecting for large heads the proportionate size of the stalks must always be considered. Not the largest head alone, but the largest possible head on the smallest stalk is the most desirable selection. The grain sorghums are for use where limited rainfall is the principal controlling factor in grain production. Larger plants use and transpire more water than smaller ones. Selection should be made where the stand is uniform and fairly thick, and should include the largest and best heads produced under such conditions. They should not be made from the outer row of the field or plat, or from places where the stand is thin, even though the larger heads are found in such places. From 6 to 7 inches of row for each stalk is considered the proper spacing for milos and 9 to 10 inches for kafirs in the higher plains.

Average weight of heads.—The average weight of heads varies with the stand and seasonal conditions. Close spacing of stalks in the row or an unfavorable growing season reduces the size of the heads, even if they are well filled. Wide spacing and favorable conditions cause larger and heavier heads. Under average field conditions the heads of milo and Dwarf milo weigh from 3 to 4 ounces and those of durra varieties about 3 ounces each. In the kafir group the heads are normally much heavier, weighing from 4 to 6 ounces, while kowliang heads vary between 3 and 4 ounces each.

Percentage of Grain in Total Crop.[1]

The percentage of grain in the total crop varies greatly with the character of the season in which the crop is grown and with the stand of stalks. Some experiments indicate that under ordinary conditions milo and Dwarf milo will produce from 35 to 40 per cent of their total weight in the form of grain. In Blackhull kafir, and probably Red kafir also, the average will be about 25 per cent, on account of the heavy stalks and leaves of the kafirs. For the kowliangs the proportion will be about the same as in milos. One plat of milo at the Dalhart Experiment Farm, Texas, in 1908 yielded 47.2 per cent of its weight in grain. Three plats yielded above 40 per cent. On the other hand, in seasons of drought or other unfavorable conditions the percentages of grain may fall to one-half or less of the averages given above.

Freedom from Suckers and Branches.

All sorghums apparently have the habit of producing both suckers and branches. There is, however, considerable difference among the groups and varieties in this regard. Suckers seem to be produced normally, branches only under somewhat exceptional conditions. They will be discussed separately.

[1] See Bulletin 203, Bureau of Plant Industry, U. S. Dept. of Agriculture, entitled "The importance and improvement of the grain sorghums," by Carleton R. Ball, for a discussion of tabulated results.

Suckers.—These are produced from the closely crowded lower nodes or joints of the stem, just at the surface of the ground. They appear in some cases almost as early as the main stalk itself and in other cases not until the main stalk is well grown or even after it has begun to mature its seed. They may vary in number from 1 to 10 or 15, according to the habit of the plant or to the particular environmental conditions, such as abundance of food, moisture, etc. Though their heads are usually smaller, suckers differ from the main stalk chiefly in height and earliness. They are usually rather lower and almost always later in maturing, often very much so. Where the latter part of a season is more favorable than the earlier, suckers often grow taller than the main stalk. Their difference in stature is objectionable only in harvesting, but their late ripening is a more serious matter.

The value of suckers in grain-sorghum crops is still a debated question. Many of the advertisements offering the seed of these crops dwell at length on their power to produce several stalks from one seed. Considering the cheapness of the seed of grain sorghums and the exceedingly small quantity (2 to 4 pounds) needed to plant an acre, the grower can well afford to require only a single stalk from a single seed. In a forage crop, where abundance of leaves is wanted, suckers may be very desirable, but in a grain crop requiring little seed the weight of evidence is against them. Their existence may be partly justified by their help in making a fuller crop where a thin stand occurs. This is largely offset by their somewhat later maturing. It is a question whether the seed produced really pays for the food and moisture used.

Selections should then be made with the object of entirely removing suckers. This can best be done by selecting heads from stalks which produce none. In case the crop on which selection is begun does not contain any stalks wholly without suckers, the selection should be made from stalks which have only a single sucker or in which the suckers are very small and appear very late in the season. In this way the tendency to produce them will gradually be overcome. Closer planting in the drills will also have this effect. The combined effect of these two methods will materially reduce the numbers.

Branches.—The stems of all sorghums, like those of corn, are made up of alternate joints, called nodes, and elongated sections of nearly round stem called internodes, meaning literally "between the nodes." The peduncle is the rather long section of the stem which grows from the uppermost node and bears the main head. A leaf arises at each node. The lower part of each leaf is called the sheath and is a collar which tightly incloses the internode for some distance above the joint or node from which it grows. A little bud is borne at every node except the uppermost, which bears the main peduncle instead. These buds lie snugly in a little furrow in the internode, with the leaf sheath wrapping them like an overcoat. When conditions are favorable, these buds develop into branches.

Branches are most likely to be produced when the weather remains warm and moisture is abundant late in the season. The uppermost bud develops first, the young branch forcing its way out at the top of the leaf sheath or by splitting the back of the sheath. It then rapidly elongates, putting out leaves and finally a terminal seed head.

It thus becomes a miniature stalk, growing on the parent stalk and exactly like it in all respects except size. Meantime the buds at the successively lower nodes have been making similar growth. If the season is long enough and the moisture sufficiently abundant, all these developing buds will become fruit-bearing stalks. In extreme cases the lateral buds on the oldest or uppermost branches will themselves develop into branches. This compound branching could go on indefinitely if permitted by seasonal conditions.

The heads on these branches are much smaller and less productive than those on the main stalk. They are also much later in maturing. Advertisements which state that a single stalk produces from four to ten large heads are wholly misleading. The branches themselves, arising first from the upper nodes, make the plant top-heavy and likely to lodge. The presence of branches interferes with the harvesting of the grain. It often delays the maturing of the main head. Branches also use water that should remain in the ground for the use of the next crop, without making any adequate return. They are therefore wholly objectionable and should be prevented by selection and proper planting wherever they tend to occur.

BETTER METHODS OF PRODUCTION.

Only methods of planting and the proper cultivation of the crop will be treated here. Rotations and general tillage to conserve moisture have their influence on crop improvement. In a new country, however, strict rotation systems can not be followed, and the general methods of dry farming need not be given in this paper. The principles are two: (1) Till so as to absorb the rainfall and (2) till so as to prevent evaporation. This subject has been fully treated elsewhere.[1]

Proper stand or row space.—The whole question of the proper stand or row space for the different varieties under different conditions of soil and moisture is one of which little is yet known. It is not the plant having the largest head which makes the biggest acre yield, but the plant which can produce the largest head while growing in the smallest possible row space.

The results of four years' experiments at the Amarillo Experiment Farm, Amarillo, Tex., indicate that in general the kowliangs yield best with a stand of 1 stalk in each 5 or 6 inches of row; the milos and durras with 1 stalk in each 7 or 8 inches of row; and the kafirs with 1 stalk to each 9 or 10 inches of row In all cases the rows are 3½ feet apart, and as far as possible the seeds are dropped singly in the rows (fig. 11). Under these conditions improved varieties in each of these three distinct groups give approximately the same yields. The Amarillo Experiment Farm has an elevation of 3,600 feet and an average annual rainfall of 22 inches, the larger part of which comes during the growing season. Further investigations, continuing the experiments through a longer period of years, may discover that better average yields will be produced at other spacings than those noted above.

It is probable that at other locations better results will be secured at other rates of planting than those given for Amarillo The rate

[1] See Farmers' Bulletin 256, entitled "Management of Soils to Conserve Moisture," which will be sent free on application to the Secretary of Agriculture, Washington, D. C., or to any Member of Congress

will vary with different elevations, different amounts of annual rainfall or a different proportion of it during the growing season, and with differences in the character of the soil.

Drills or hills.—Another important question which has not yet been made the subject of experiment to any extent is the comparative value of planting in drills and in hills. For instance, 1 stalk every 6 inches in the row, or 2 stalks in a hill every foot, or 3 stalks in hills 18 inches apart, or 4 stalks in a hill and the hills 2 feet apart would all give the same number of stalks per acre. Would they give the same results in bushels of grain per acre? The answer is not known. All the evidence at hand indicates that the advantage is in favor of a single

FIG. 11.—Plat of Brown kowliang, showing stalks singly and evenly spaced in the row.

stalk in a place. Experiments with corn seem to show that where from 3 to 5 kernels are planted in a hill better results are secured when the kernels are scattered a few inches apart instead of being dropped in a bunch.

Aside from the immediate question of yields, however, there are other reasons for preferring planting in drills rather than in hills. These reasons are connected with the production of suckers and pendent heads. Observations indicate that the fewest suckers and pendent heads to the stalk are produced where the stalks stand singly. Whether this be true or not, it is certain that where the stalks stand one in a place it is much more easy to determine whether suckers are produced and to take steps to get rid of them by selection.

Planter plates.—The difficulty of securing proper rates of planting is partly due to an idea persisting in the minds of growers and partly to lack of suitable plates. When the former is corrected, the latter can be easily obtained. The first sorghums extensively cultivated in this country were the sorgos, which are forage crops and as such are planted thickly. The other leading groups, the milos and kafirs, were also first regarded as forage plants and sown quite thickly. Corn planters were equipped with "cane" plates which dropped 10 to 25 seeds in a foot of drill. In this way the idea of thick seeding for sorghums became firmly fixed in the minds of growers.

The value of the milos, kafirs, and durras as grain producers was only gradually recognized. The necessity of planting thinly where high grain yields were desired was realized even more slowly. Though this necessity is now being seen by the great body of grain-sorghum growers, there is not yet knowledge and agreement as to the proper rates of planting. These vary with different conditions and must be made the subject of extensive experiments. Meantime the manufacturers of planters, though recognizing the demand for different plates, have had little data on which to create a suitable supply.

So far as the size of the seeds is concerned, probably only two sets of plates will be necessary in order to drop a single seed at a time of any variety. The two sets will have the holes of different sizes and perhaps of slightly different shapes also. Milos and durras have rather large seeds, more or less round in outline. Kafirs and kowliangs have smaller and more nearly oval seeds.

Having these two sets of plates, certain variations in the rate of planting will be necessary in order to space properly the seeds of different varieties in the drill. For instance, the seeds of kafirs and kowliangs will drop singly through the same hole, but the kafirs should be planted 10 inches apart and the kowliangs only 5 or 6 inches. This variation in rate is secured in two ways: (1) By the adjustment on the planter which changes the speed of the plate and (2) by using plates drilled with different numbers of holes. Where plates with the proper number of holes are not purchasable, blank plates can be secured and drilled by a blacksmith. Care should be taken that the holes are countersunk on the lower side of the plate so that seeds will not become wedged in them.

ADAPTABILITY TO MACHINE HANDLING.

More than ever is it true that the demand is strong for crops which may be handled readily and profitably by machinery at every stage in their production. This has long been true of the small-grain crops. Corn and cotton are examples, however, of two great staple crops which must still be gathered by hand. However, many and varied efforts are being made to produce machines which will gather the ears of corn and the lint-covered seeds of the cotton.

If the grain sorghums are to become staple crops on a large scale they must be adapted to machine handling. In the early years of the cultivation of milo and kafir as important crops, there were two methods of harvesting in vogue where seed was desired. The first was to cut the crop, stalk and all, with the corn binder and cure it in the shock.

The heads were then cut from the bundles with a knife, saw, or hatchet. The second method was to cut the heads by hand in the field. This was done with a knife and the heads were thrown into a wagon body, like ears of corn. Both these methods are in common practice to-day.

HEADERS.

Some years ago there was invented a header designed for use in heading kafir. Though still in use to some extent, it has never been a popular or widely used machine. It is rather heavy, not running upon its own gear, but attached instead to the side of the wagon box. It is heavy and hard to handle, destructive to the wagon bed, and not susceptible to quick and wide adjustments. Moreover, it heads but a single row at a time and is rather expensive, considering all these points. It can not be used on milo because of the large number of pendent heads, or on Dwarf milo because of its low growth. In recent years many attempts have been made to invent a satisfactory row header which would be free from the objectionable features mentioned. So far these efforts have not been successful, though one of the machines gives considerable promise.

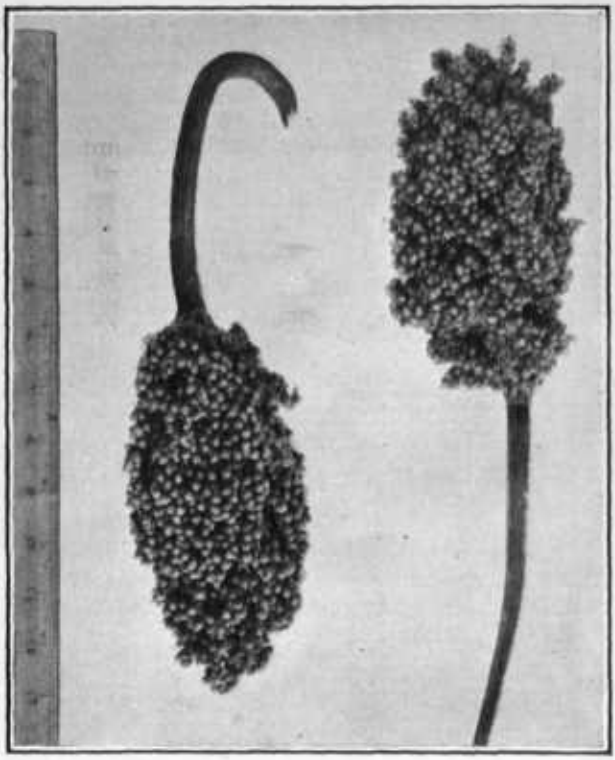

FIG. 12.—Milo heads; one pendent, one erect.

Since the introduction of Dwarf milo it has been found possible to harvest it rapidly and satisfactorily by means of the ordinary grain header. The standard milo and the kafirs are too tall for easy handling with this machine. A few ingenious farmers have, however, contrived to raise their headers on planks to a point where they will gather these taller crops with a fair degree of satisfaction. One great advantage of the grain header is that it enables the farmer to harvest his small grains and his feeding grains with the same machine. As it cuts a number of rows at a time, the work is done rapidly and a large area is easily handled.

Two facts still prevent the general use of the grain header for these crops, viz, their height and the presence of pendent heads in some varieties. Here is a problem in selection for the farmer. Dwarf strains of kafir must be perfected to equal the Dwarf milo already so popular. Varieties with erect heads must be had in all milos and durras.

PENDENT HEADS.

There are four great groups of grain-producing sorghums now under cultivation in this country. These are milo, durra, kafir, and kowliang. The first two groups originally had pendent or "goosenecked" heads (fig. 12). In the last two groups the heads are normally erect. The durras are but little grown because of the wasteful shattering of the seed, the irritating hairs on the glumes, and the pendent heads. A strain of White durra has been perfected in which 100 per cent of the heads are erect under all conditions. Improvement in the milos has not progressed so far. The percentage of erect heads varies from 50 to 95, depending, perhaps, more upon the character of the season than on the particular strain. This character does not yield readily to selection. It doubtless can be entirely eliminated, however, by long-continued selections.

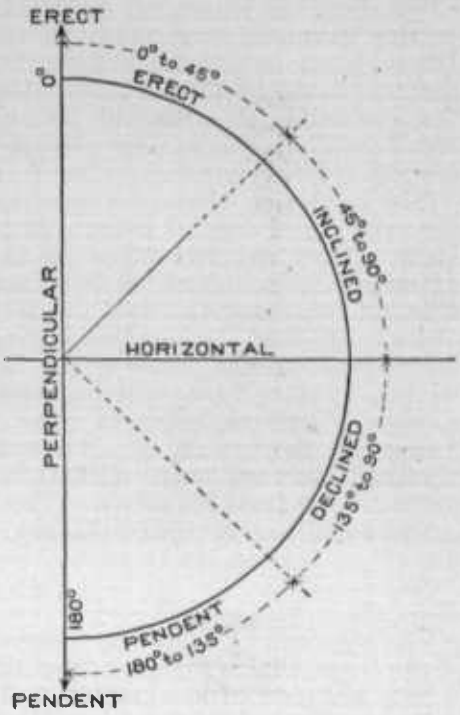

FIG. 13.—Diagram showing the named positions of heads of milo or durra.

Pendent heads seem to be the result of deep-seated habit in the plant. Because the largest, heaviest heads are most likely to be pendent, some persons believe that the bending is caused by the weight of the head. This is not true. The peduncle, or stem bearing the head, often begins to turn down as soon as the head comes out from the boot and before it is at all heavy with seed. Strong, vigorous stalks are most likely to produce pendent heads. Enough desirable stalks bearing erect heads can usually be found, however, to allow selections for erectness.

Our experiments show that the planting of these crops rather thickly in drills tends to prevent too great a vigor of growth and therefore checks the production of pendent heads without decreasing the yield. With the same number of plants per acre, those planted in hills appear to produce more pendent heads than those spaced evenly in drills.

The diagram shown in figure 13 is tentatively suggested as an aid to those who are recording results in breeding these crops. The

half circle through which the head may pass in shifting from the absolutely erect to the absolutely pendent position is divided in this diagram into four sectors of 45 degrees each. The head not inclined more than 45 degrees from the perpendicular is called erect, and is so for all practical purposes of harvesting. Between 45 degrees and the horizontal it is called inclined, and in the first 45 degrees below the horizontal it is called declined, while below that it is called pendent. Though all such heads are not really pendent, the header must be set about as low in order to harvest them as if they were hanging straight downward.

GIVE THE BOYS A CHANCE TO SELECT GRAIN-SORGHUM SEED.

Complaint is commonly made that the children are not interested in the farm and that many of them leave it as soon as possible. Interest can be awakened by giving the boys and girls something definite to do in the way of improving the farm and its products. Once started, they should be encouraged to feel responsible for results. They should also receive a money return, however small, for the improvement resulting from their efforts.

The formation of various boys' and girls' clubs, especially those for the growing of corn, is helping to create interest in the things of the farm. They are real steps in the right direction and should be extended to cover all farm crops, poultry, and live stock. But it is not necessary to await the formation of a neighborhood club in order to interest the boy in selecting better seed. Help him to make selections from the year's crop. Let him prepare it for storing over winter. Set aside a field on which he can plant it the following spring. Plant alongside it some unselected seed. Assist him in comparing the two fields. Encourage him if striking results are not obtained the first year. Give him a fair share of the profit when profit results from his labors. The best result will be the increase of interest and knowledge in the boy.

SUMMARY.

The "grain-sorghum belt," broadly speaking, is the southern half of the Great Plains region, nearly 400 miles wide and 1,000 miles long.

It is a region of low rainfall and high evaporation, of varied soils and considerable elevation, with correspondingly shortened seasons. It is suited to become a noted stock-feeding region.

The grain sorghums, including milos, durras, kafirs, and kowliangs, are of recent introduction and have become important only within the last 20 years. By their earliness, drought resistance, and adaptability they are especially fitted for growth under Plains conditions.

Sorghum grain is largely used for feeding stock on the farms where it is grown. Its feeding value is nearly equal to that of corn. The protein content averages higher than that of corn, the fat and fiber content lower.

Any surplus is readily marketed as whole grain or as chops for feeding purposes.

Sorghum grain is in much demand for poultry food, for which it is admirably suited. Over 25 per cent of the ingredients of prepared poultry foods in the eastern United States is kafir grain.

It seems probable that the meal can be used as readily as corn meal for human food and that both the meal and flour can be used in mixtures with wheat flour if desired.

Kansas and Oklahoma grow annually over 1,250,000 acres. It is probable that an equal area is grown in Texas also.

The grain-sorghum acreage in Kansas is nearly 10 per cent of the corn acreage and in Oklahoma over 12 per cent.

More than half the kafir and over 95 per cent of the milo is grown on the dry lands west of the ninety-eighth meridian. In this region the proportionate acreage of grain sorghums to corn is steadily increasing.

In spite of the less favorable conditions under which much of the crop is grown, the average acre value of the grain sorghums in Kansas is higher than that of corn, and in Oklahoma it is 70 per cent as great.

The grain sorghums may be greatly improved through the selection of better varieties and the use of better methods.

Improvement will be chiefly in the direction of (1) drought resistance, (2) earliness, (3) dwarf stature, (4) productiveness, including erect heads and freedom from suckers and branches, and (5) increased machine harvesting.

The drought resistance of the grain sorghums is very important. It is probably a combination of several characters, some actually drought resistant, as controlled transpiration and a strong root system, others only drought evasive, as earliness and dwarfness.

Improvement in earliness is necessary in adapting the crop to regions having a short growing season. Early plants take advantage of early seasonal rainfall and also have lower water requirements.

Milos, White durra, and some Brown kowliangs are normally early. Two early strains of Blackhull kafir have been produced, one tall and one dwarfed.

Dwarf stature lowers the water requirement of the crop and permits heading by machinery. Dwarf varieties are now to be had in all groups.

Better yielding varieties may be produced by selecting for well-shaped, well-filled heads, fully exserted from the boot and as large as possible in proportion to the size of the stalk.

The value of suckers in the grain-sorghum crops is doubtful. They are often shorter and usually later in maturing. Seed is so cheap and so little is used per acre that only a single stalk from each seed need be required.

Branches are utterly worthless for grain production in proportion to their objectionable features and should be eliminated.

Experiments show that under Panhandle conditions kowliangs give best yields with a stand of one stalk to each 5 or 6 inches of 3½-foot rows; milos and durras each 7 or 8 inches, and kafirs each 10 inches. Under different conditions the spacing will need to be varied somewhat.

Better results are probably secured from plants single in the drill than from the same number of plants in hills. Single stalks are also more easily selected and harvested and seem to produce fewer suckers.

To plant single seeds of the different grain sorghums two sets of plates are needed, with holes of different sizes, one set for milos and durras and one for kafirs and kowliangs.

To space different varieties properly in the drill, speed adjustments on the planter or plates with different numbers of holes will suffice.

The ordinary grain header harvests low varieties, like Dwarf milo, with complete success. The invention of satisfactory row headers or the growing of other dwarf varieties will solve the harvesting problem finally.

Pendent heads are usual in some varieties. They can be slowly eliminated by selection and proper planting.

The boys of the farm should be interested in seed selection to improve farm crops. Give them a chance with the grain sorghums.

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